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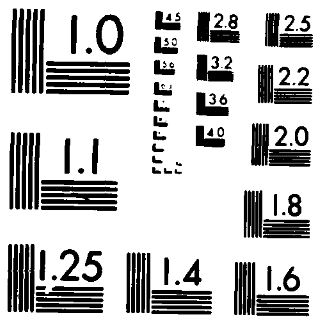

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FOREIGN TECHNOLOGY DIVISION

AIR FORCE SYSTEMS COMMAND

THE OVERALL STATE AND OUTLOOK FOR THE DEVELOPMENT OF DIGITAL SYSTEMS IN POLAND

by

Jan Kolodziejczak and Bogdan Czajka

FOREIGN TECHNOLOGY DIVISION

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The Overall State and Outlook for the Development of Digital Systems in Poland

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The Greater Polish Telecommunications Electronics Works, TELKOM-TELETRA, in Poznań

Digital telecommunications transmission systems based on the time division of information channels and pulse code modulation have won a permanent place for themselves in the telecommunications networks of many countries. There has been a particularly heavy development of this kind of equipment in countries leading in telecommunications and having at their disposal an advanced contemporary electronics base. The evolution of digital systems is an excellent example of conditioning influences extending between recent telecommunications technology and the present level of the development of subsystems technology.

The principle of pulse code modulation (PCM) was presented and patented in 1938 by Reeves, but the technological state of electronics at that time, as well as the area of telecommunications services, did not make it possible to develop the technical and economic bases for the practical exploitation of this patent.

The invention of transistors and their introduction into mass production created the favorable conditions for the development of many varieties of telephone equipment with pulse code modulation in the 1950's, and the development of integrated digital circuit products made possible the serial production of this kind of equipment and its general introduction initially into local telephone nets, and then subsequently, also into interurban nets. At the same time, the International Consultative Committee on Telephones and Telegraphy (CCITT) commenced the normalization work for digital telephone systems during the 1960's, and as a result of this, their hierarchies on the basis of the 24-channel and 30-channel telephone equipment complexes were established in 1972. Equipment from the first group was introduced by countries which were most advanced in the development of digital systems into their networks, that is, the United States and Japan, and the equipment in the second group was adapted by the European countries.

Work has been taken up in Poland as well with the intention of mastering

the production of multichannel pulse code modulation equipment and introducing it into operation. This has been carried out on the basis of the close cooperation between the group of workers in the Institute of Communications in Warsaw and the Greater Polish Telecommunications Electronic Works, TELKOM-TELETRA in Poznań, which has continued this activity in the area of the further development of digital systems up to the present time.

Twenty-four-channel type TCK 24 equipment was developed in the first place. The introduction of this system into production and its exploitation took place in stages determined by the availability of semiconductor elements of national production, because a principle of restricting imports of subsystems used in this kind of equipment to an absolute minimum had been adopted.

In the years 1969 and 1970, functional models of this kind of equipment were developed, first of all on the basis of germanium transistors, and then subsequently on the basis of silicon transistors -- in accordance with their production at that time by national industries. After the start-up of the production of integrated digital systems in our country had been begun, a third version of the TCK 24 equipment was developed on the basis of this; this version has now been adopted into serial production and operation.

Between the years 1976 and 1977, more than 2,000 TCK 24 digital system channels were installed in our country, initiating a new qualitative step in Polish telecommunications. The modernization of networks by using the TCK 24 equipment made it possible to automate the telephone traffic of many telecommunications centers, such as, among others, Warsaw, Gdańsk, Poznań, and Katowice, as well as making it possible to provide service to those regions that were only just becoming acquainted with the most recent technology in the area of telecommunications transmissions, and to gather valuable experience before successive stages in the development of the Polish network and the introduction of digital electronic commutation into it.

The introduction of TCK 24 equipment into operation in the presently existing network was connected with a broad series of difficulties arising from, among other things, the poor state of cables in local networks, a lack of appropriate

control, monitoring, and measuring devices, nonuniformity in the codes for individual automatic Strowger exchanges in different switching centers, the poor quality of certain subsystems used in the equipment complexes, as well as incorrect operational organization (disregarding the scale of this disorder). Thanks to the efforts of the users' services, as well as the efforts of the equipment producers, these bad features in the system have been removed, and at the present more than 150 TCK 24 multichannel terminals installed in the district administration jurisdictions of Gdańsk, Warsaw, Poznań, Katowice, Wroclaw, Lublin, Szczecin, and Kraków are in operation in the national network.

The type TCK 24 equipment is specified for multiplexing urban and district lines on the principle of time division in the channels. One of the positive features in this system makes it possible to produce 24 telephone links using two cable pairs at distances from several to several tens of kilometers. The 24 channels in the TCK 24 system are principally specified for the transmission of telephone signals; however, they can also be used for telegraphic transmission and data transmission with small traffic capacity. The racks from the type UK-TCK 24 terminal equipment and the type SR-TCK 24 [1] regenerator stations are compatible with the TCK 24 system. An auxiliary installation is the PKT-TCK 24 line control device. The UK-TCK 24 rack with its full complement includes two multichannel terminals, that is, equipment for 48 channels, as well as for 48 quasi-electronic translations. The multichannel terminals play a basic role in the system, such as channel multiplexing on the time division principle, changing analog signals to a seven-element binary code, adjusting the signal for transmission in the line by producing a bipolar AMI code with a bit rate of 1,544 kbit/s, as well as by recreating the initial form of the analog signals on the receiving end. Quasi-electronic translations make it possible to carry out direct cooperation between TCK 24 multichannel terminals and the selectors at the automatic Strowger exchanges in using the bits specially designated for this purpose (the first of eight bits in the channel width).

At the beginning of the 1960's, another PCM basic system was normalized by the CCITT upon the suggestion of several European countries; this system is a 30-channel system. It has been generally adopted throughout the European region and has been approved by the Warsaw Pact countries. Work involved with this kind of

equipment was taken up in Poland in 1973, and its introduction into production and exploitation will be the second stage in the development of telecommunications transmission digital systems in our country. The significance of this kind of equipment grew, especially after the acquisition of licenses for the production of E-10 electronic central exchanges based on a 30-channel PCM system; this significance also has to do with the level of analog-digital conversion, and made itself felt in the area of inter-exchange digital links. The level of advancement in the design and construction work at that time with the TCK 30 system (as it was designated) made it necessary to give up any hope of acquiring licenses for similar kinds of equipment from the CIT Alcatel firm, which saved our government more than one million American dollars.

TCK 30 equipment is specified for the same purposes as the TCK 24 system; however, the main function of this equipment at the present level in the development of Polish telecommunications is to assure transmission routes within the framework of E-10 electronic exchange central networks, as well as between them and cooperating analog electromechanical centrals. One TCK 30 set makes it possible to realize 30 telephone links by means of two cable pairs. In accordance with present CCITT recommendations, a code word in each channel is made up of eight binary elements, assuring better transmission quality in comparison with the TCK 24 system.

The transmission lines of the TCK 30 system have been adapted for the transmission of signals with a bit rate of 2,048 kbit/s coded in HDB-3.

The following equipment is included in the TCK 30 system:

- UK-TCK 30 terminal equipment racks,
- UT-TCK 30 translation racks,
- SR-TCK 30 straight-through regenerator stations.

Six multichannel terminals, that is, 180 PCM channels, are placed in a terminal equipment rack, together with local and remote feeder cables for the power feed of equipment working together on the transmission lines. One hundred eighty of these units are installed in a translation rack, providing cooperation between the TCK 30 equipment and the appropriate electromechanical centrals. A regenerator

station comprises six bidirectional straight-through regenerators, as well as a breakdown localization set. The TCK 30 equipment has found a permanent place in the Polish telecommunications network and is becoming the basis for its increasing digitalization.

After putting the third E-10 electronic system central in Poland into operation, there were about 300 TCK 30 multichannel terminals installed in UK-TCK 30 racks operating around Poznań and Lódź serving four inter-central links; some of these were also installed in E-10 concentrator racks. In the network for both centers, in addition, straight-through regenerators have been active installed in about 200 regenerator stations, as well as more than 3,000 GAS translations, working together with Strowger type centrals: the K 66 and the Salme.

The TCK 30 system -- as the *basic system* in the hierarchy of digital equipment -- will be systematically updated and further developed. In addition to the work having to do with the successive elimination of imported subsystems, systems making it possible to exercise continuous control over coder operations have also been developed, as well as adaptive equipment, by means of which it will be possible to expand the service system for purposes of data transmission over lines of great traffic-bearing capacity. In place of a single or even several telephone call channels, an appropriate number of data transmission channels with 64 kbit/s bit rates can be realized in a codirectional system or in a contradirectional system, in accordance with the G 732 provision from CCITT.

A type TCC 120 system of secondary multiplexing has been developed on the basis of the TCK 30 equipment, having a line signal bit rate of 8,448 kbit/s and making it possible to realize 120 telephone channels by means of two cable pairs. This equipment makes it possible to simultaneously multiplex four signals with bit rates of 2,048 kbit/s into a single cumulative signal with a bit rate of 8,448 kbit/s, which is then sent to an adjacent station, where the four basic signals are demultiplexed with their initial bit rates. Secondary multiplexing in the TCC 120 system is carried out on the basis of executing a positive signal in accordance with the G 742 provision of CCITT.

The TCC 120 equipment is designated for local and inter-urban networks, and

it has been adapted for working together with type A1TKDNXpx multiwire digital cables produced by our national industry. The TCC 120 system includes the following equipment [2]:

- UK-TCC 120 terminal equipment racks, in which eight secondary multiplexing multichannel terminals are placed, for 960 digital channels;
- UL-TCC 120 terminal line equipment racks holding 12 line ends with terminal regenerators and remote feeder cables;
- SR-TCC 120 straight-through regenerator stations, for six or 12 regenerators.

In addition, the following equipment is included as well: a line tester for the remote control of straight-through regenerators, as well as cyclical control equipment making it possible to carry out continuous testing of the multichannel terminals without interrupting the ongoing transmission of all channels. The introduction of the TCC 120 system into exploitation has involved many serious difficulties (brought about by delays in the production of multiwire cable); however, once they have been overcome, this equipment will find broad use within the network. In accordance with the plans of the Ministry of Communications, it is foreseen that more than 150 TCC 120 sets will be installed between 1980 and 1990, including both cable links and radio links.

In the telecommunications transmission digital equipment named up to the present time, most of the electronic subsystems used are from home production, including small-scale integrated digital circuits, as well as a medium level of integration. Further intentions in the area of developing digital systems, having to do with the increasing network demands as well as worldwide tendencies in this area, are conditioned to a great degree by progress in the area of producing subsystems in Poland, and particularly in the area of specialized large-scale integrated circuits, as well as in the area of producing Schottky diode systems with small current consumption. In the framework of systems with large multiplication factors, it is foreseen that the third order TCC 480 480-channel digital multiplexing equipment will be introduced into production, having line signal traffic capacities of 34,368 kbit/s and adopted for working together with small dimension coaxial cable, as well as together with radio links. This equipment complements the TCC 120 system

that has already been introduced at the present time in response to greater demands for digital channels.

On the basis of integrated coder-decoder-filter-amplifier channel systems and regenerators, the development and introduction into production of the so-called third generation TCK 30 system is foreseen. The integrated circuits that contained the systems named above are already being produced by a broad series of world firms, such as: Intel Corporation, Siliconix, Mostek GmbH, Motorola Semiconductors, National Semiconductor, and others, and their introduction into PCM systems results in lowering production costs, increases in reliable operation, and a considerable degree of miniaturization in these systems. The features named above will also be possessed by the TCK 30 second generation equipment, in which, in addition, account is taken of the new expanded CCITT recommendations, which are the subject of studies at the present time and which will be adapted in their compulsory forms in 1981.

According to present predictions, 30-channel PCM equipment will become the basic system in telecommunications transmission in digital networks over the long run; however, on the basis of current CCITT studies, the appearance of subscriber digital systems with differential pulse code modulation (DPCM) should also be expected; in these systems, a subscriber's connection with a commutation central or with a multichannel terminal is carried out by means of digital line with traffic capacities of, for example, 32 or 64 kbit/s.

For the purpose of facilitating cooperation between digital systems with the analog systems used generally up to the present time, the TN 60/2 x TCK 30 transmultiplexer is being developed and introduced into production in our country; it facilitates the direct transfer of secondary analog groups with 30-channel digital groups. This equipment plays a fundamental role in the integration of the existing analog network with the digital network being developed, and it assures, among other things, direct communications between regions with electronic commutation by means of long-haul analog carriers not involving signal conversion to the acoustical band. The development of a 1,920-channel fourth order TCC 1920 multiplexing system with a line signal traffic capacity of 139,264 kbit/s is foreseen for a further stage in the development of digital systems; it can be adapted for working together with normal-dimension and small-dimension coaxial

cable. The TCC 1920 system is designated for making up long-haul digital links, and at the same time, together with the already specified equipment complexes, it will assure the digitalization of all levels in the telecommunications network in our country.

For the purpose of using digital systems for the transmission of nontelephone signals as well, the development of wide-band coding equipment designated for analog-digital and digital-analog radio broadcasting and television broadcasting signal conversion is also foreseen. The use of radio broadcasting coding equipment assures the transmission of a single monophonic program in bands of five telephone channels or a single stereophonic program in place of 10 telephone channels in a TCK 30 multichannel terminal. The possibility of using TCK 30 line carriers is also foreseen for the transmission of six monophonic channels or three stereophonic channels. Television signal coding equipment makes possible the transmission of color television signals using TCC 480 line carriers with the use of differential pulse code modulation (DPCM).

A separate problem, connected with the introduction of digital systems into the existing telephone network, involves the translations that adapt commutation signal codes for the individual types of automatic exchanges into forms making it possible to use them together mutually as the means used in multichannel telephone equipment with pulse code modulation. The types of relay translations and quasi-electronic translations produced in Poland at the present time for the TCK 30 and TCK 24 systems have been adapted for working together with analog PCM channel contact points, as well as together with the transmitting and receiving signal conductors assigned to them. The great variety in signal codes used in the exchanges in Poland necessitates the use of many kinds of translations with an optimized number of installed relays characterized by relatively great reliabilities.

For the purpose of restricting the number of types of translations, as well as for more easily adapting them for the various kinds of signal codes, it is foreseen that the family of electronic translations will be developed and introduced into production. This equipment assures that it will be possible for electromechanical exchanges to work together with various kinds of systems, as well

as for the electronic exchanges of the E-10 system to work together with the existing analog network. Electronic translations and communications between different groups of signalling equipment will result in an integrated programmed system using the large-scale integrated memory systems PROM and REPROM. Cooperation and co-working between these kinds of equipment and TCK 30 multichannel terminals will be carried out by means of S 16 time interval signals with traffic capacities of 64 kbit/s.

Table 1. Digital telecommunications translation systems for cable with symmetrical carriers

Administration	Traffic capacity (kbit/s)	Line code	Level of use
ATT (USA)	6,312	B6ZS	in use
ATT (USA)	3,152	AMI	in use
ATT (USA)	1,544	HDB-3	in use
NIT (Japan)	1,544	AMI	in use
GTE (USA)	3,152	AMI	in use
Denmark	8,448	HDB-3	in use
Sweden	8,448	HDB-3	in use
Sweden	2,048	HDB-3	in use
Sweden	704	HDB-3	prototypes
West Germany	2,048	HDB-3	in use
Great Britain	2,048	HDB-3	in use
France	2,048 (1st generation)	HDB-3	in use
France	2,048 (2nd generation)	HDB-3	experimental line
France	8,448	HDB-3	in use
Finland	2,048	HDB-3	in use
Italy	8,448	HDB-3/AMI	in use
Poland	2,048	HDB-3	in use

Table 2. Digital telecommunications transmission systems for microdimension coaxial cable of the 0.7/2.9 mm type

Administration (organization)	Traffic capacity (kbit/s)	Line code	Level of use
ITT	34,368	MS43	not determined
Italy	8,448	HDB-3	in use
Italy	34,368	MS43 modified	experimental line
Philips	8,448	HDB-3	in use
Philips	34,368	FOMOT (4B3T)	in production

Table 3. Digital telecommunications transmission systems for micro-dimension coaxial cable of the 1.2/4.4 mm type

Administration (organization)	Traffic capacity (kbit/s)	Line code	Level of use
France	51,747	HDB-3	serial production
France	139,264	4B3T	in use
Great Britain	120,000	3-level	in production
NTT (Japan)	97,728	AMI + scrambler	in use
Philips	139,264	FOMOT (4B3T)	not determined
Philips	34,368	FOMOT (4B3T)	in production
ITT	139,264	6B4T	in development
ITT	-565,000	6B4T	under study
Italy	34,368	MS43 modified	in use
Italy	139,264	7-level	experimental line
Italy	139,264	MHS 43	experimental line
West Germany	34,368	MHS43 (4B3T)	in use

Table 4. Telecommunications transmission systems for normal-dimension type 2.6/9.5 mm coaxial cable

Administration (organization)	Traffic capacity (kbit/s)	Line code	Level of use
Canada	274,176	B3ZS	in use
Philips	139,264	FOMOT (4B3T)	connected with 12 MHz FDM system
NTT (Japan)	97,728	AMI + scrambler	in use
NTT	400,352	AMI + scrambler	in use
West Germany	-565,000	AMI + scrambler	experimental
ITT	139,264	6B4T	in development
ITT	-565,000	6B4T	under study
ATT (USA)	274,176	2-level	in use since 1975
Italy	139,264	7 level	experimental line
Italy	139,264	MHS 43	experimental line

Table 5. Digital telecommunications transmission systems for fiber optical cable

Administration (organization)	Traffic capacity (kbit/s)	Line code	Level of use
ATT	44,736	binary + scrambler	improvement studies since 1977
France	34,368	CMI	experimental line since July 1976
France	139,264	CMI	experimental line since May 1977
Italy	140,000	binary + scrambler	experimental line since September 1977
Italy	560,000	binary + scrambler	experimental line since June 1978
NTT	32,064	binary RZ + scrambler	laboratory experiments since January 1977
GTE	44,736	binary + scrambler	improvement studies since February 1979
GTE	1,544	binary	improvement studies since April 1977
Belgium	34,368	NRZ 5B/6B	improvement studies since October 1978
Belgium	139,264	NRZ 5B/6B	improvement studies since May 1979
ITT	139,264	17B-18B	improvement studies since June 1977
Philips	139,264	5B/6B	experimental line since May 1975
Plessey	8,448	3B/4B + scrambler	experimental line since June 1978
ITT	8,448	2B-3B low density	experimental line since July 1978
ITT	1,544	1B-2B	improvement studies since March 1978
ITT	44,736	17B-18B	improvement studies
CTCA (Canada)	6,312	2B-3B	experimental line
CTCA (Canada)	274,176	NRZ	experimental studies

The program presented here for the development of digital telecommunications systems emerges from projections from branches of communications technology connected with electronic commutation, as well as from telecommunications electronics plans in the area of the continuous updating and modernization of equipment produced. The sequence and deadlines for carrying out the individual themes presented here have been recently established on the basis of present feasibilities

for providing industry with the necessary subsystems, as well as assuring home-originated deliveries and import deliveries. At the same time, it is necessary to keep in mind that in making allowances for the actual possibilities in the Polish electronics industry, the assurance of competitive levels in contemporary PCM equipment requires appropriate hard-currency expenditures for the purchase of specialized subsystems and control and measurement equipment. The ideas accepted in our country at the present time concerning the development of telecommunications transmissions digital systems are in accordance with present-day tendencies in worldwide technology in the area of telecommunications, and they take account of present possibilities inherent in Polish industry.

Because of their decisive advantages, digital systems have already come to predominate in the networks of many advanced countries — both within the area of basic 24- and 30-channel equipment, as well as in systems with higher channel capabilities — on a scale and in hierarchies compatible with the needs and conditions of each administration and using economically justified transmission media (coaxial and symmetrical cable, fiber optical cable, radio lines, etc.). The Tables 1 to 5 present tabulations of the digital systems used and produced by certain governments and firms within the world. This tabulation has been put together on the basis of current reports forwarded to CCITT within the framework of studies undertaken during the period 1977-1980.

At the same time, together with the development of telecommunications transmissions digital systems shown in the tables presented here, the services afforded by this equipment in other areas are shown as well, for example, in nontelephone information areas such as radio broadcasting, video signal transmission, and television. In connection with this, a series of world firms produces (or is in the process of developing) appropriate wide-band coding equipment for working together with multichannel terminals in determined hierarchies, or together with digital transmission lines.

The introduction of large-scale integrated circuits containing self-contained unitized coder and decoder systems, as well as channel and regenerator systems, has made it possible to significantly miniaturize this equipment and to reduce energy consumption; in the next stage, subscriber links will be digitalized, and

telephone, telegraphic, and computer communications services will be integrated.

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